

TOWARDS AN IMPROVED HIGH RESOLUTION GLOBAL LONG-TERM SOLAR RESOURCE DATABASE

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ABSTRACT

This paper presents an overview of an ongoing project to develop and deliver a solar mapping processing system to the National Renewable Energy Laboratory (NREL) using the data sets that are planned for production at the National Climatic Data Center (NCDC). NCDC will be producing a long-term radiance and cloud property data set covering the globe every three hours at an approximate resolution of 10 x 10 km. NASA, the originators of the Surface meteorology and Solar Energy web portal are collaborating with SUNY-Albany to develop the production system and solar algorithms. The initial result will be a global long-term solar resource data set spanning over 25 years. The ultimate goal of the project is to also deliver this data set and production system to NREL for continual production. The

project will also assess the impact of providing these new data to several NREL solar decision support tools.

1. INTRODUCTION

Considering the possibility of global climate change and the global competition for energy resources, there is an increasing need to provide improved global Earth surface solar resource information. The capability to improve and produce long-term records is needed to better understand and quantify potential shifts in the solar resource with changes in climatic weather patterns. Toward this end a project was funded under the NASA Applied Science program involving the National Aeronautics and Space Administration (NASA), National Renewable Energy Laboratory (NREL), the State University of New

York/Albany (SUNY) Atmospheric Science Research Center (ASRC) and the NOAA National Climatic Data Center (NCDC) to provide NREL with a global long-term advanced global solar mapping production system for improved depiction of historical solar resources and variability and to provide a mechanism for continual updates of solar resource information. This new production system is made possible by the efforts of NOAA and NASA to completely reprocess the International Satellite Cloud Climatology Project (ISCCP) data set that provides satellite visible and infrared radiances together with retrieved cloud and surface properties on a 3-hourly basis beginning from July 1983. The old version of the ISCCP data provided this information for all the world's available geosynchronous satellite systems and NOAA's AVHRR data sets at a 30 km effective resolution [1]. This information plus additional atmospheric information was used in NASA GEWEX Surface Radiation Budget project to produce the first global long-term maps for solar irradiance at a 1x1 degree resolution which became the basis for the NASA's Surface meteorology and Solar Energy web portal (SSE, [2,3]). This new version will provide a new and improved satellite calibration at an effective 10 km resolution. Thus, working with SUNY, NASA will develop and test an improved production system that will enable the longest-term global solar resource database to date at 10 km spatial resolution.

This paper provides an overview of this project together with early results. Since production of the ISCCP has been shifted and is being tested at NCDC, we will contrast some of the new features of the planned 10 km data set relative to the current 30 km data set. We will also show some of the early results in the testing and validation of the improved algorithms from SUNY and NASA that will use this new ISCCP data set. Lastly, we will identify the next steps in the production of the data set including some accuracy goals for which the effort is aiming.

2. IMPROVED ISCCP DATA

As noted above the current version of ISCCP, denoted DX, has been used to produce global estimates of the solar resource. Under support from both NASA and NOAA, the ISCCP project is in the process of improving this data set by a) improving the process of inter-calibrating the visible and thermal infrared radiances from the world's geosynchronous and polar orbiting imagers, b) improving several important inputs (such as aerosols, meteorological profiles and surface properties, and c) providing satellite radiances and retrieved cloud and surface properties at all pixels. Furthermore, the ISCCP is delivering the algorithms and production software to NCDC for production and archival of the new data products. Some sample products from NCDC have already been produced. Figure 1 provides an illustration of the differences in sampling between the current ISCCP DX version that contains 8 – 10 km pixels subsampled to 30 km

and the new version that will contain all pixels (pixel size varies slightly on the satellite instrument and channel). The horizontal density of the product together with the 3-hourly sampling will provide an opportunity for a long-term solar resource data set at higher resolution than has been obtainable.

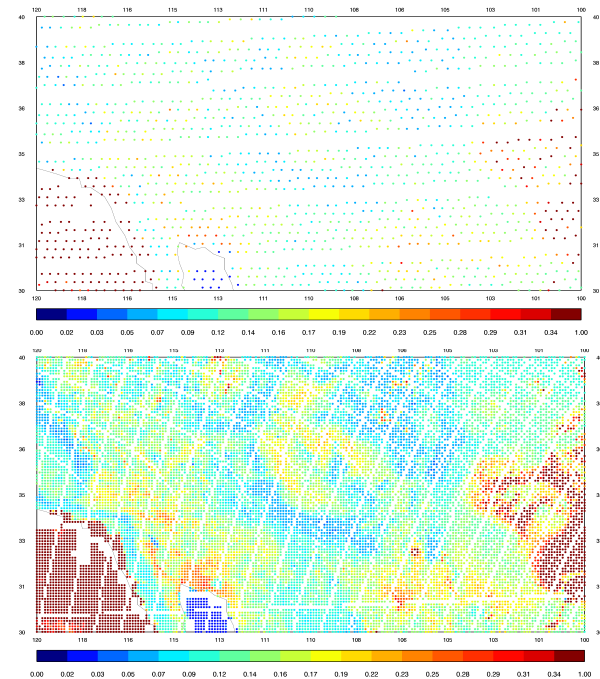


Fig. 1: Visible radiances from GOES-10 from the current ISCCP DX (top panel) and the near future revised ISCCP (bottom panel) for the Southwestern US/Northwestern Mexico (Baha California on bottom left) on June 1, 2001, 18Z.

3. INITIAL RESULTS WITH ISCCP B1U

To obtain an early test of the eventual data products, the current version of the ISCCP B1U is being tested [4]. The ISCCP B1U data set, prepared and archived by NCDC, contains the full ISCCP 8-10 km resolution by satellite for the world's geosynchronous platforms (i.e., US GOES, Japan's GMS, Europe's METEOSATs). This data set does not contain the expected improved inter-calibration, cloud properties nor any polar orbiting data sets from NOAA's AVHRR imager. However, together with ancillary data sets, there is enough data to evaluate the application of the SUNY ASRC solar algorithm [5] to this data set. First results of this testing are given in Figure 2. In Figure 2, the top panel shows a scatter plot of the ASRC Quad Pixel Count directly from GOES-10 to the ISCCP B1U radiances computed from GOES-10 image. The scattering is most

likely due to the difference in effective pixel size between the two input radiance data sets. The ASRC Quad Pixel is a 1 km pixel subsampled to 10 km while the ISCCP B1U pixel is an actual effective 10 km pixel. Despite the scatter there is good linearity between the two data sets. This implies that the ASRC algorithm can be applied to the ISCCP B1U data as is for evaluation. The result of that calculation is shown in the bottom panel of Figure 2 comparing the first solar fluxes computed directly from the ASRC algorithm using ISCCP B1U data against surface measurements at the Penn State NOAA SURFRAD site [6].

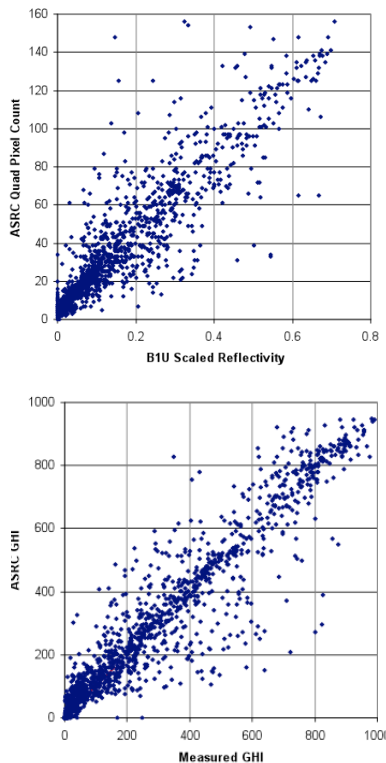


Fig. 2: The top panel shows the scatter between the SUNY ASRC Quad pixel data and the ISCCP B1U scaled radiance. The linearity (despite scatter – see text) means that the SUNY ASRC solar algorithm can be applied using the ISCCP B1U data. Verification is shown in the bottom panel where ASRC output using ISCCP B1U is compared to SURFRAD measurements at the Penn State site in W m^{-2} .

5. PROPOSED PRODUCTION SYSTEM

The eventual production of a long-term solar resource capability that will be delivered to NREL for production will require a considerable amount of ancillary data besides the ISCCP data sets. Data products such as column water

vapor, ozone, snow/ice cover, aerosol optical properties, surface ground cover and reflectivity are important to the quality of the data products. To facilitate this, a production strategy has been devised and is shown in Figure 3. Work to date has aimed at providing these inputs and the development of the production code. For instance, a time series of the Total Solar Irradiance has been constructed using the new finding of the NASA SORCE (Solar Radiation And Climate Experiment) mission that the solar constant is approximately 1361 W m^{-2} [7]. Addition-ally, a new blended global ozone data product has already been developed for the production. Tests of various sources of column water vapor information are underway. One source being evaluated is the Modern Era Retrospective-analysis for Research and Applications (MERRA, [8]). Lastly, a global background aerosol climatology is being prepared that can be augmented with important aerosol events in time, such as from volcanic aerosol. Prototypes from these various inputs are shown in Figure 3 which also depicts the production flow of the data sets to temporally averaged solar flux data products.

6. FUTURE WORK

Results to date are preliminary but show promise for using the next improved version of the ISCCP data set to produce a global long-term map of the solar irradiance. More specifically, the next steps are planned during the course of this project are outlined below:

- Continued testing of the ISCCP B1U data set using the SUNY ASRC model and comparing both to surface measurements and currently available data sets from SRB and SUNY.
- Continued development of ancillary input required for the long-term production of the data products
- Continued development of the production system by adapting current production systems in collaboration with SUNY.
- NASA/SUNY and NCDC collaborate to assess new ISCCP data products and incorporate into the production system.
- Testing of both SUNY and NASA solar algorithms using the new data sets via comparison to surface measurements
- Evaluation of the new products by comparing against currently available solar irradiance products available from the National Solar Radiation Data Base (NSRDB)

The goal of this work is the complete production and delivery to NREL of the most advanced global solar resource data products and capability possible. Allowing for the continual production of the solar resource should provide the means to continue to update these solar resource databases into the future.

NASA Solar Mapping Climatological Data Sets

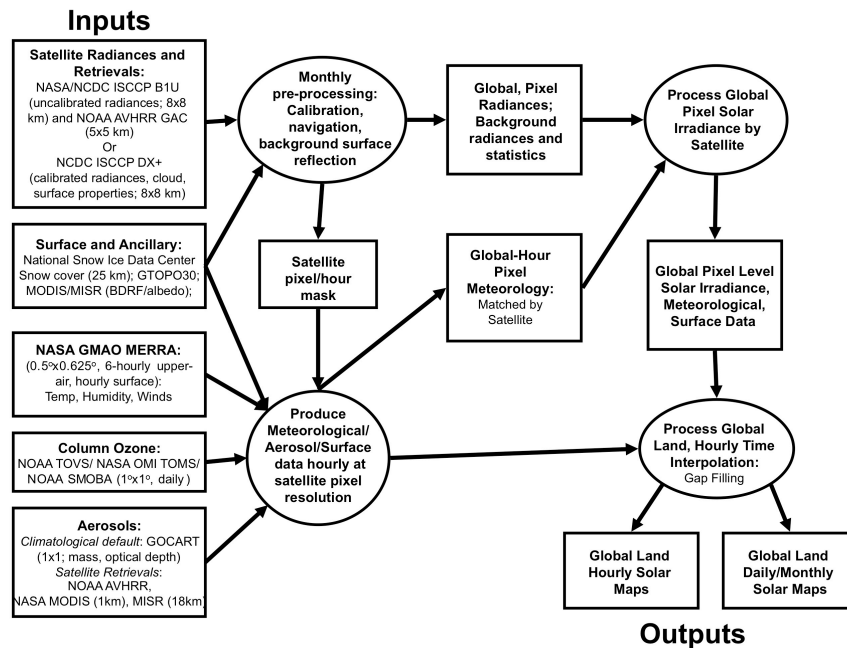


Fig. 3: The proposed production system for the development of solar resource data products from the near-future and improved long-term ISCCP satellite radiance and cloud data set. The data product record would commence in July 1983 and span as close to present as possible. This new ISCCP will be processed directly by NCDC and the solar resource production system will assess NASA and SUNY ASRC solar algorithms to derive the new data products.

7. ACKNOWLEDGEMENTS

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